Channel Equalization System And Method

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I. Related Applications

This application is a divisional of U.S. patent application serial number 09/550,395, filed on 4/14/2000, attorney reference 4871, which is a continuation-in-part of U.S. provisional application serial number 60/170,455, filed on 12/13/99, attorney reference 4630.

This application is also a continuation-in-part of U.S. patent application number 09/444,007, filed on 11/19/99, attorney reference 4571; which is a continuation-in-part of U.S. Patent application number 09/417, 528, filed on 10/13/99, attorney reference 4511; which is a continuation-in-part of U.S. provisional application number 60/104,316, filed on 10/13/98, attorney reference 3659; and which is a continuation-in-part of U.S. provisional application number 60/109,340, filed on 11/20/98, attorney reference 3697.

This application is also a continuation-in-part of U.S. patent provisional number 60/129,314, filed on 04/14/99, attorney reference 3926. This application is also a continuation-in-part of PCT application number PCT/US00/06842, filed 03/15/00, attorney reference 4511 PCT.

This application is also a continuation-in-part of U.S. patent application number 09/127,383, filed on 07/31/98, attorney reference 3476 which is a continuation-in-part of U.S. provisional application number 60/089,526, filed on 06/15/98, attorney reference 3480; and which is also a continuation-in-part of U.S. provisional application number 60/085,605, filed on 05/15/98, attorney reference 3432; and which is also a continuation-in-part of U.S. provisional application number 60/054,415, filed on 07/31/97, attorney reference 2961; and which is also a continuation-in-part of U.S. provisional application number 60/054,406, filed on 07/31/97, attorney reference 2960.

Static Position Error or Jitter is caused by the error associated with the signal sampling accuracy or the proximity of the timing pulse to the optimum sampling point or to the center of the eye. To suppress this jitter, the Com2000™ Precision Sampling uses a combination of technologies, such as Channel Calibration and Measurement system (and Measurements circuits 330, 343 as shown in Fig.56) and Precision Sampling system, for placing the sampling window within a specified tolerance of the center

Imperfectly timed sampling has the similar effect of increasing AWGN noise as far as the demodulator SNR is concerned. The Com2000™ Post Equalizer signal delivers a clean and wide-open eye diagram. With a signal demodulator precision sampling window for a Non-Linear Estimator such as a multi-level Quantiser M-PAM or M-QAM Demodulator (74) accurate to a level of 1ns , therefore the Com2000™ can allow more symbols per baud on the existing N Mbaud symbol rate.

UniNet Burst Switching (Fast Circuit Switching) TDD Examples:

For simplicity, it is desired to have N equal-size time-slots (TS) in one TDMA-frame as shown in Figure 58 below.
The frame can be further divided into two sections: downstream (from Reference Node, RN to other regular Nodes) and Upstream (from regular Nodes to RN) as shown in Figure 59. Note that the boundary between 2 sections is movable and can be changed from one frame to another by the RN based on the DCA. The EMPTY ZONE occupies a number of Time-Slots (nTS) sufficient to cover the twice the longest distance in time between the RN and a regular Node. The reason for this zone will be explained later in Section 5 on Ranging. The TDMA frame structure discussed in Figure 59 is actually a TDMA/TDD (Time Division Duplexing) structure. The downstream is for point to multiple points while the upstream is for multiple points to point.
Each TS can accommodate one burst and a burst contains the pre-amble and cell as shown in Figure 60 below. Figure 60 only illustrates an example for discussions. We will need more investigations to design the detailed structures of the Burst and Cell . The pre-amble consists of:

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- G: guard time (i.e., no Tx, idle) to avoid overlapping of two consecutive bursts (Its length is therefore derived to cover the "quantization" error in ranging as discussed later),
- UW: unique word to identify the beginning of the burst. The UW of the reference node (to be discussed later) is used by the Rx Framer to identify the frame marker, and
- T: training pattern to adjust the frequency (if sent by the reference node) or to adjust the phase/timing (if sent by a regular node).

The cell contains a header (H) and a payload.

The N time-slots, TS#1 to TS#N, are shared by all nodes. The transmission in a particular TS is coordinated by the primary reference node (RN). For redundancy, there is also a secondary RN selected. The secondary RN becomes the active RN only when the primary RN fails.

Sampling Delay or Propagation delay measurements (CPR)

Consider the time at which the Reference Node sends its reference burst in TS#0 of the TDMA Frame. Let denote this time reference at the beginning of the TS#0 (called Frame Marker) as $t=0$. With respect to this time reference, a regular Node #A will receive this Frame Marker at $t=T_{RA}$ where T_{RA} denotes the time distance between the Reference Node and Node #A, including the processing time. This is the Rx Frame Marker of Node #A. Let assume $2T_{RA} < T_{timeslot}$ where $T_{timeslot}$ is the time interval of a time-slot. It becomes clear that in order for the RN receives the burst sent from Node #A at time $t=T_{timeslot}$ (i.e. right in the next time-slot), the Node #A must send its burst at time $t=T_{timeslot} - T_{RA}$. For a simple derivation, this time is also $t=T_{RA}+D_A$ where $D_A= T_{timeslot} - 2T_{RA}$. In other words, the Node #A has to wait for D_A after receiving the Frame Marker (i.e., "time" position of its Rx Frame Marker). Therefore, the time, $t=T_{RA}+D_A-T_{timeslot}$, denotes the Tx Frame Marker of the Node #A. The time relationship described above is shown in Figure 61 below.

As discussed above, to establish the Tx Frame Marker, Node #A needs only one parameter D_A. For this the RN has to perform ranging during the initialization or re-configuration for a newly entering Node #A in the following sequence.

(a) RN sends a request in its Reference Burst to ask Node A to transmit a probing burst. Of course, the RN does not know the "time" distance between itself and Node A and we do not want that the probing burst of Node A collides an active burst of another Node or of the RN. To avoid collision with the bursts originated from the Reference Node, as shown by Figure 59, no Node is allowed to send its burst before completely receiving the end of the downstream section. This is the reason for the EMPTY ZONEin Figure 59. This zone appears to be equivalent to $2T_{max}$ where T_{max} is the longest "time" distance between the RN and a regular Node .

To avoid collision with the bursts from other nodes, the RN can keep the first time-slot after the EMPTY ZONE to assign it to the newly entering Node A to send its Probing burst.

(b) Node A has to establish the Rx Frame Marker in order to receive the cells. It then receives the command from the RN and prepares to send its probing burst. For this, the Node A waits for the end of the downstream section completely received and sets up the tentative Tx Frame Marker, and then sends its Probing burst.

(c) Reference Node waits for the UW of the probing burst from Node A. When the UW is detected, the RN measure the distance in time between the received UW and time-slot marker to derive D_A. Subsequently, the RN will send the value D_A to the Node A and ask Node A to adjust and re-send the probing burst.

Normally, it must be correct in the second time. However, we need to allow for a few more times . Also note that this should be done without interruption of the network operation.

The Tx Framer receives the Rx Frame Marker and Rx Frame Sync status signals from the Rx Framer. It also receives the Tx allocated time-slot numbers from the Dynamic Capacity Allocation block. From these inputs, the Tx Framer generates the gating signals to control the transmission of the Burst-Mode Modulator. An example of the gating signals are given below. We assume a frame of 5 time-slots (i.e., N=5) and in a particular frame, time-slots #2 and #4 are assigned to this node.

Figure 63 shows the block diagram of the Rx Formatter. Its functions are:

(a) To detect and establish the received Bursts Sync via detecting Unique Word Mark.

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search mode, all data are considered, therefore false alarm (i.e., reference UW is not there but some data pattern looks identical) may happen often. To improve the performance, we only declare a UW detected if the pattern is 100% identical.

On the other hand, in the tracking mode, the node already knew the vicinity of the UW, hence the control signal provides only a narrow window for UW detection in order to reduce the false detection probability. In the tracking mode, a pattern of L bits is declared to be a UW if there are M<L identical bits. M<L to cover the case of bits in error due to noise. We need a short analysis to determine M, L.

2.2 Transport (MAC & Upper Layer) Intelligence - QoS Transfer Technology

The UniNet™ new architecture for Per-Request Fast Circuit-switched network architecture is discussed the following subsections. UniNet™ is an effort to deliver a high capacity network with packet/circuit switched transport with an integrated service environment, as illustrated in figure 02.

2.2.1 Protocols Transfer Environment : Protocol Sync Circuit Switching Tech

A. Brief Summary of Services problems

Standard Internet Protocol (IP)-based networks provide "best effort" data delivery by default. Best-effort IP allows the complexity to stay in the end-hosts, so the network can remain relatively simple [e2e]. This scales well, as evidenced by the ability of the Internet to support its phenomenal growth. As more hosts are connected, network service demands eventually exceed capacity, but service is not denied. Instead it degrades gracefully. Although the resulting variability in delivery delays (jitter) and packet loss do not adversely affect typical Internet applications–email, file transfer and Web applications— other applications cannot adapt to inconsistent service levels. Delivery delays cause problems for applications with real-time requirements, such as those that deliver multimedia, the most demanding of which are two-way applications like telephony.